Exploring College Students’ Deeper Learning Perceptions in the Blended Learning Environment: Scale Development, Validation, and Experimental Comparison

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ABSTRACT

With the rapid development of information communication technology (ICT) in teaching, deeper learning has become an essential competency for success in the 21st-century classroom. College students’ deeper learning assessments can indicate the degree of technology-enhanced learning effectiveness and inform further instructional design optimization. However, comprehensive measures for assessing college students’ deeper learning and the impact of background variables on deeper learning in the low-, medium-, and high-blend learning environments are scarcely mentioned in the literature. This paper proposes a deeper learning self-assessment scale (DLSS) comprising higher-order cognitive, interactive, and reflective learning dimensions, validated through exploratory and confirmatory factor analyses. This paper also examines deeper learning perceptions in three types of blended learning environments with various proportions of online and face-to-face learning and explores perception differences among the students of different genders, school years, and fields of study. Findings indicated positive deeper learning perceptions were higher in the medium-blend courses.

KEYWORDS

Blended Learning Environment, College Students, Deeper Learning, Deeper Learning Self-Assessment Scale, Higher-Order Cognitive Learning, Interactive Learning, Reflective Learning, Scale Development

INTRODUCTION

Twenty-first century skills, such as innovation, information, media, technology, life and career skills, have become essential for thriving in the digital age (Karakoyun & Lindberg, 2020). Cultivating these skills to meet professional and societal demands requires that higher educational institutions go beyond core knowledge mastery (Wu & Zhu, 2017) and emphasize knowledge internalization and
its transfer to engage college students in deeper learning (Hernández et al., 2019). Deeper learning entails learning independently, thinking critically, as well as transferring and applying knowledge flexibly to solve complex problems (Karakoyun & Lindberg, 2020).

The prevalence of advanced technologies enabled the construction of blended learning environments conducive to deeper learning. For instance, small private online courses (SPOCs) and flipped classrooms shifted the focus from traditional teacher-centered instruction to student-centered learning (Xiao-Dong & Hong-Hui, 2020) and let students become active and interactive learners (Ustun & Tracey, 2020). Furthermore, Verdonck et al. (2019) found that such environments encouraged group work and self-directed learning while Heilporn et al. (2021) suggested that supportive digital tools and frequent online assessments promoted student behavioral engagement in blended learning courses.

Previous studies focused mainly on the strategies, models, and factors, which influence deeper learning in specific blended learning courses (Bi & Shi, 2019; Chen et al., 2018; Ustun & Tracey, 2020). Few studies comprehensively assessed college students’ deeper learning perceptions in blended learning environments, and the impact of the background differences on deeper learning in the learning environments of various blend types. Therefore, this study uses a validated deeper learning self-assessment scale (DLSS) to evaluate Chinese college students’ perceptions of deeper learning in blended learning environments and to explore their background differences.

This paper is organized into five sections. The next section provides theoretical background on deeper learning and blended learning in higher education, which underpins the DLSS. In the following section, we present the research methodology employed in this study. Then, the paper details the results of scale validation and experimental comparisons. Finally, the last two sections cover the discussion of the findings and suggestions for future implementation and further research.

**LITERATURE REVIEW**

**Deeper Learning**

Deeper learning is an evolving concept defined as the process of taking what was learned in one situation and applying it to new situations. It stems from the concept of deep-level processing (Marton & Säljö, 1976) and focuses on understanding, elaborating, critical thinking, and information synthesis (Biggs, 1979). Furthermore, in terms of corresponding 21st-century skills, deeper learning can be classified into six dimensions (William and Flora Hewlett Foundation [WFHF], 2013) and three domains (National Research Council, 2012). According to the framework for evaluating deeper learning (Huberman et al., 2014), the cognitive domain encompasses deep content knowledge, critical thinking and problem-solving dimensions, the interpersonal domain collaboration and communication dimensions, and the intrapersonal domain learning-to-learn and academic mindset dimensions.

Deeper learning has been positively associated with cognitive development and with higher-order thinking skills (Lee & Choi, 2017; Todd et al., 2019), which deals with ill-structured problems or complex tasks (Huberman et al., 2014). According to the revised Bloom’s taxonomy of cognitive objectives, “remembering and understanding” belong to lower-order cognitive learning, while “applying, analyzing, evaluating, and creating” belong to higher-order cognitive learning. Furthermore, engaging online students in higher-order cognitive learning encourages them to use various tools and techniques to solve problems, and to successfully evaluate, analyze, and synthesize information from multiple sources (Dwyer & Walsh, 2020). For students to understand the key principles and apply them to new situations, ample opportunities to complete challenging tasks must be provided (WFHF, 2013). For instance, improving students’ higher-order cognitive learning could be accomplished by integrating real-world scenarios and internship experiences into instruction (Huberman et al., 2014).

Deeper learning also emphasizes communication and collaboration. These complementary skills require high engagement (Hernández et al., 2019) and can be used to identify and create solutions for a broad range of challenges (Al-Samarraie & Saeed, 2018). As an important instructional strategy,
collaborative learning emphasizes learner-centered instruction and has a positive impact on students’ learning performance (Chadha, 2019; Molinillo et al., 2018). Such tasks as student presentations, group work, and interactive projects provide students with opportunities for effective communication and meaningful engagement with the learning content (Mthethwa-Kunene et al., 2022). Vázquez-Cano et al. (2020) found that college students were more apt at communicating through interactive presentations, as well as at collaborating online through mobile devices. Wang et al. (2021) found that students learned more actively and effectively through online and face-to-face interactive activities in the immersive and supportive blended learning environment.

Besides, deeper learning highlights students’ reflective learning, described as the recognition of what one is doing (Schön, 1983). It requires students to examine the past, present, and future learning processes, and to look inward (Mumford & Dikilitaş, 2020). Nelson et al. (2006) suggested that reflective learning is an important indicator of students’ deeper learning, which benefits students in many ways and enables them to achieve better academic performance and learn more actively and deeply (Kanellopoulou & Giannakoulopoulos, 2020). For instance, actively monitoring learning processes and using appropriate strategies boosts learning content comprehension (Heilporn et al., 2021), and reflective practice encourages rational decision-making and positive learning behavior (Colomer et al., 2020). Deeper learners should have a strong reflective capacity to form habitual reflective consciousness and learn to reflect on their learning processes and results to monitor, adjust, remedy, and improve their deeper learning skills (Mumford & Dikilitaş, 2020). According to López-Pellisa et al. (2021), learning through reflection is associated with collaborative work, which enables students to learn more by observing and evaluating the work of their classmates.

A review of the related literature revealed that deeper learning is a broad concept, which encompasses higher-order cognitive learning, interactive learning, and reflective learning. In this study, the authors operationally define students’ learning activities involving application, analysis, evaluation, and creation as higher-order cognitive learning, students’ learning through discussion, communication and collaboration as interactive learning, and students’ learning by monitoring and directing their own behavior as reflective learning. The authors explore students’ perception of deeper learning through the three dimensions.

**Blend Learning in Higher Education**

Blended learning is an approach that combines the advantages of face-to-face and online learning (Garrison & Kanuka, 2004; Rasheed et al., 2020). Allen et al. (2007) argued that for a course to be blended, between 30% and 79% of the learning content should be delivered online. As blended learning enhances perceived attention and confidence, and boosts perceived satisfaction level, it is viewed as superior to both pure online and face-to-face learning (Ma & Lee, 2021). The key to effective blended learning is the implementation of various information and communication technology tools and resources (Wang et al., 2021). When used for experience-sharing and collaborative learning, communication tools enhance behavioral and emotional engagement (Heilporn et al., 2021). Virtual reality and cloud computing technologies, on the other hand, facilitate student-centered learning and offer engaging learning experiences for students to meet their personalized needs (Singh et al., 2021). Therefore, the authors define blended learning as the process of systematic and continuous engagement in a course, where 30% to 79% of the learning content is delivered via digital platforms or tools, and where online and classroom-based interventions are deliberately combined to facilitate productive learning. Alammary et al. (2015) thought that the proportion of online to face-to-face components incorporated into the blended course was vital for students’ performance. Bernard et al. (2014) divided the online proportion into two categories (up to 30% and 30% to 50%) and found that the higher the online proportion, the better students’ achievement. Owston and York (2018) suggested that students performed better in blended courses when about 33% to 50% of learning was online, but more research was needed to determine whether a 50% blend was the optimal proportion of online time for a blended course. For this study, the authors classified the courses with 30% to
40% of online delivery as low-blend learning environments, 41% to 60% as medium-blend learning environments, and 61% to 79% as high-blend learning environments.

Numerous researchers have highlighted the effectiveness of various blended learning approaches in promoting college students’ deeper learning (Buitrago & Chiappe, 2019; Chao et al., 2021; Heilporn et al., 2021; Taghizadeh & Hajhosseini, 2021). For instance, combining massive open online courses (MOOCs) and team learning was observed to promote learners’ active participation and enable them to engage with materials more comprehensively (Akoglu et al., 2019), whereas learning in a flipped classroom was associated with better achievements, improved interactions among students, and more opportunities for active learning (Verdonck et al., 2019; Wang & Zhu, 2019). Similarly, Le Roux and Nagel (2018) reported that when college students in blended flipped courses access online videos and resources before class and engage in collaborative inquiry activities in class, they cultivate deeper learning by applying their theoretical knowledge to problem solving. In a similar vein, Li and Cao (2020) revealed that VR-supported flipped English classrooms not only improves students’ overall cultural literacy but also spurs their personal development. Yaniawati et al. (2022) developed a mathematical learning application that increased students’ high-order thinking and divergent thinking skills.

However, some studies have reported that blended learning environments have no obvious influence on students’ learning outcomes. According to Wang and Zhu (2019), students’ self-direction did not change in the MOOC-based blended environment. Furthermore, Cabi (2018) reported that flipped classroom learning did not significantly differ from traditional learning in terms of students’ academic performance. These inconsistencies may be due to background variable differences and various blend types. Therefore, it is necessary to examine students’ perceived deeper learning and explore the differences among students of different genders, school years, and fields of study in the low-, medium-, and high-blend courses. Based on the literature review, this paper focuses on the following questions:

1. What are college students’ deeper learning perceptions in the blended learning environments? Do students in the low-, medium-, and high-blend learning environments perceive their deeper learning differently?
2. Do students of different genders, school years, and fields of study perceive their deeper learning differently? Do the different blended learning types explain the observed differences?

**METHODOLOGY**

**Research Procedure**

The authors developed the DLSS, revised and validated the proposed model, and used its modified version to measure perceived deeper learning in the blended learning environments. Furthermore, they examined the impact of background variables on students’ perceived deeper learning in the three types of blended learning environments (Figure 1).

**Participants**

The participants in this study were 1,290 students from 8 universities in 8 Chinese provinces, recruited through purposive sampling. All of the participants participated in at least one blended course and completed 30% to 79% of their learning online. All blended courses were delivered in Chinese, participants’ first language. Participants were informed of the research purpose and were asked to indicate to what extent they agreed with each item presented. They were told that there was no right or wrong response; instead, they were asked to provide responses that best suited their situation. The authors developed an online questionnaire (Figure 2), which was shared with authors’ colleagues employed at eight universities in eight Chinese provinces, who, in turn, distributed it to their students.
over four weeks, at the end of the spring semester in 2021. A total of 1,015 valid responses were obtained, with a healthy return rate of 78.68%. The sample comprised 479 males and 536 females aged between 18 and 23, of whom 331 were freshmen, 340 sophomores, 174 juniors, and 170 seniors; 610 students majored in humanities and social science disciplines and 405 in natural science disciplines.

**Instruments**

The online questionnaire featured 22 questions and statements in Chinese. It was self-reported and comprised two parts.

Part A probed basic information such as gender, age, school year, and field of study to gauge students’ self-perceived deeper learning. In addition, students’ instructors were asked to estimate the blend type of courses their students were enrolled in. According to the collected questionnaires, the respondents majored either in the humanities and social sciences field disciplines, such as philosophy, economics, sociology, literature, education, management, psychology, and art, or in the natural science field disciplines, such as mathematics, physics, chemistry, biology, and material science.

Part B examined students’ self-perceived deeper learning in a blended learning environment. A deeper learning self-assessment scale (DLSS) in a blended learning environment was designed based on a compatible framework and related literature. All the items were scored on a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree).
Scale Validation

According to Lynn (1986), 3 to 10 experts are required for content validity. Thus, three educational technology experts with eight or more years of professional experience were invited to review the items. Afterwards, cognitive interviews were conducted with 10 college students to ensure the test items’ comprehensibility. Based on the expert and student feedback, some items were deleted or appropriately revised to improve readability, relevance, and clarity. The resulting 18 items (Table 1) measured students’ experiences in blended learning environments. The first six items (Q1–Q6), which belonged to the higher-order cognitive learning dimension, assessed how well specific learning content was understood, transferred, and applied, and measured students’ self-perceived critical thinking and creative problem-solving skills (Dwyer & Walsh, 2020). The next six items (Q7–Q12) comprised the interactive learning dimension and measured students’ ability to communicate in an oral or written form, listen to and express various opinions, solve academic or occupational problems, and complete tasks collaboratively (Gabaldón-Estevan, 2020). The remaining six reflective learning dimension items (Q13–Q18) measured students’ perceptions of their ability to reflect on their learning processes and methods (Cho & Littenberg-Tobias, 2016).

Phase One: Exploratory Factor Analysis

Pilot test participants were recruited by one of the authors and her colleagues at a normal university in South China, where they taught. Out of 264 recruited college students with blended learning experiences, 212 students completed and turned in questionnaires with valid responses, yielding a robust return rate of 80.30%.

An exploratory factor analysis (EFA) was performed to test the factor structure of the DLSS. The Kaiser-Meyer-Olkin value was 0.95, and Bartlett’s chi-square value was $\chi^2 (153) = 2860.69, p < 0.001$, indicating that the EFA could be performed. Eigenvalues > 1 were set as a criterion for factor extraction while factor loadings > 0.50 were used for item retention.
A principal component analysis with varimax rotation produced three factors (Table 2), which explained 70.19% of variance. The scale had an overall reliability coefficient of 0.96 and high alpha values ($\alpha > 0.80$) for each individual subscale (Table 1), indicating acceptable reliability. The interactive learning (IL) dimension comprised six items with factor loadings of 0.66–0.81, which explained 56.86% of variance. The higher-order cognitive learning (HCL) dimension featured six items with factor loadings of 0.60–0.82 and accounted for 7.04% of variance. The reflective learning (RL) dimension included six items with factor loadings of 0.51–0.82 and explained 6.29% of variance. The results indicated good structure validity.

**Phase Two: Confirmatory Factor Analysis**

The scale was further tested on a new set of students. Out of 512 recruited students, 405 provided valid responses, with a healthy return rate of 79.10%.

<table>
<thead>
<tr>
<th>Items*</th>
<th>IL</th>
<th>HCL</th>
<th>RL</th>
<th>Cronbach’s $\alpha$</th>
</tr>
</thead>
<tbody>
<tr>
<td>In a blended learning environment:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q1: I can apply what I have learned to solve new tasks.</td>
<td>0.64</td>
<td></td>
<td>0.92</td>
<td></td>
</tr>
<tr>
<td>Q2: I can find logical relationships between knowledge points.</td>
<td>0.61</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q3: I can correctly judge opinions on a topic from different sources.</td>
<td>0.60</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q4: I can find new ways to solve problems.</td>
<td>0.82</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q5: I can infer from what I have learned and argue in a sensible way.</td>
<td>0.81</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q6: I can use what I have learned to describe a problem and develop a hypothesis.</td>
<td>0.73</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q7: During the group discussion, I can pinpoint the learning task problems.</td>
<td>0.66</td>
<td></td>
<td>0.92</td>
<td></td>
</tr>
<tr>
<td>Q8: I can listen carefully to my peers’ opinions on a problem.</td>
<td>0.72</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q9: I can offer useful suggestions on my peers’ questions.</td>
<td>0.72</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q10: I can use forums actively to share my ideas with my peers.</td>
<td>0.81</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q11: I can collaborate with my peers to complete tasks.</td>
<td>0.76</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q12: I can work with my peers to define steps for solving a problem.</td>
<td>0.74</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q13: After interacting with teachers/peers, I can spend some time thinking about what they said.</td>
<td></td>
<td>0.62</td>
<td>0.89</td>
<td></td>
</tr>
<tr>
<td>Q14: I can analyze the reasons for failure to solve problems.</td>
<td></td>
<td>0.64</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q15: I can examine the strengths and weaknesses of a solution I’ve developed for a problem.</td>
<td></td>
<td>0.51</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q16: I am able to adjust my learning methods during the learning process.</td>
<td></td>
<td>0.71</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q17: I can review the discussion of a topic on the forums.</td>
<td></td>
<td>0.82</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q18: I can recognize my strengths and weaknesses by reflecting on my learning experience.</td>
<td></td>
<td>0.82</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Eigenvalues: 10.24 1.27 1.13
Variance (%): 56.86 7.04 6.29
Cumulative Variance (%): 56.86 63.90 70.19

*Originally in Chinese. The items were translated into English for readers’ convenience
AMOS 26.0 was used to perform a confirmatory factor analysis (CFA). The CFA tested the goodness of fit of the proposed 18-item model. For a model fit to be considered acceptable, the indices must reach the required thresholds: $\chi^2/df < 5$ (Wheaton et al., 1977), GFI and AGFI $> 0.80$ (Wu et al., 2020), TLI and CFI $> 0.90$ (Hu & Bentler, 1999), as well as RMSEA and SRMR $< 0.08$ (Browne & Cudeck, 1992). The CFA results suggested that the 18-item model had a poor fit (Table 2). The AGFI index (0.788) was below the recommended level while the RMSEA index (0.094) was higher than the suggested maximum.

Phase Three: Model Modification and Retesting

According to Jöreskog and Sörbom (1996), the higher the modification indices (MI) are, the higher will $\chi^2$ be after deleting corresponding items. The MI values suggested that the deletion of three items would improve the fit of the model. Therefore, Q1, Q12, and Q18 were deleted from the higher-order cognitive learning, interactive learning, and reflective learning dimensions, respectively. All the fitness indices for a revised 15-item model reached the recommended levels, suggesting an acceptable fit (Table 2).

The 15-item model demonstrated satisfactory composite reliability (CR > 0.70), adequate convergent validity (AVE > 0.50), and good internal consistency (Cronbach’s $\alpha > 0.80$) values (Table 3). All the items had factor loadings above the suggested threshold of 0.50 (Peterson, 2000). The results indicated acceptable values for the higher-order cognitive learning factor (CR = 0.92; AVE = 0.69; $\alpha = 0.92$), the interactive learning factor (CR = 0.89; AVE = 0.61; $\alpha = 0.88$), and the reflective learning factor (CR = 0.90; AVE = 0.65; $\alpha = 0.90$), as well as for the overall deeper learning dimension (CR = 0.92; AVE = 0.80; $\alpha = 0.95$).

Data Analyses

First, SPSS 25.0 was used to conduct a repeated measures one-way analysis of variance (ANOVA). It evaluated the overall college students’ deeper learning perceptions in blended learning environments. Then, a one-way multivariate analysis of variance (MANOVA) was used to investigate the perception differences in the low-, medium- and high-blend courses across the three DLSS dimensions. Finally, a two-way MANOVA was performed to examine the background differences among the different blend types in three dimensions. To measure the effect size, the authors reported $\eta^2$. The values of $\eta^2 = 0.01–0.07$ represented a small effect size, $\eta^2 = 0.07–0.14$ a medium effect size, and $\eta^2 > 0.14$ a large effect size (Cohen, 1992). Moreover, to calculate the effect size for pairwise comparisons, Cohen’s d was adopted; $d = 0.2–0.5$ demonstrated a small effect size, $d = 0.5–0.8$ a medium effect size, and $d > 0.8$ a large effect size (Cohen, 1988).

RESULTS

Deeper Learning Perceptions

The mean scores for higher-order cognitive learning (M(SD) = 3.58(0.63)), interactive learning (M(SD) = 3.79(0.63)), and reflective learning (M(SD) = 3.80(0.63)) indicated that college students

Table 2. Confirmatory factory analysis: Goodness-of-fit indices

<table>
<thead>
<tr>
<th>Model Type</th>
<th>$\chi^2$ (df)</th>
<th>$\chi^2$/df</th>
<th>GFI</th>
<th>AGFI</th>
<th>TLI</th>
<th>CFI</th>
<th>RMSEA</th>
<th>SRMR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goodness-of-Fit</td>
<td>&lt; 5</td>
<td>&lt; 5</td>
<td>3.80</td>
<td>3.80</td>
<td>3.90</td>
<td>3.90</td>
<td>&lt; 0.08</td>
<td>&lt; 0.08</td>
</tr>
<tr>
<td>18-Item Model</td>
<td>599.99(132)</td>
<td>4.55</td>
<td>0.836</td>
<td>0.788</td>
<td>0.908</td>
<td>0.921</td>
<td>0.094</td>
<td>0.045</td>
</tr>
<tr>
<td>15-Item Model</td>
<td>267.72(87)</td>
<td>3.08</td>
<td>0.914</td>
<td>0.882</td>
<td>0.951</td>
<td>0.960</td>
<td>0.072</td>
<td>0.041</td>
</tr>
</tbody>
</table>
who had been exposed to blended learning exhibited positive deeper learning perceptions in all dimensions (Table 4). The repeated measures one-way ANOVA results revealed significant differences among the dimensions, with a medium effect size ($F(2,1014) = 118.48, p < 0.001, \eta^2 = 0.11$). Students’ perceptions of deeper learning in the interactive learning and reflective learning dimensions were significantly higher than in the higher-order cognitive learning dimension ($d = 0.40$ and $d = 0.45$, respectively).

To explain the differences further, the authors examined the perception differences among the students in the low-, medium-, and high-blend courses in three dimensions (Table 5).

In the higher-order cognitive learning dimension, the mean scores for the low-, medium- and high-blend courses ($M = 3.51$, $M = 3.64$, and $M = 3.46$, respectively) differed significantly, with a small effect size ($F(2,1012) = 8.12, p < 0.001, \eta^2 = 0.02$). Students’ higher-order cognitive learning perceptions in the medium-blend environments were significantly higher than those in the low- ($d = 0.21$) and high- ($d = 0.29$) blend environments.

Table 4. Deeper learning dimension differences

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Items</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>F</th>
<th>Post Hoc</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCL</td>
<td>5</td>
<td>1015</td>
<td>3.58</td>
<td>0.63</td>
<td>118.48***</td>
<td>IL &gt; HCL, RL &gt; HCL</td>
</tr>
<tr>
<td>IL</td>
<td>5</td>
<td>1015</td>
<td>3.79</td>
<td>0.63</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RL</td>
<td>5</td>
<td>1015</td>
<td>3.80</td>
<td>0.63</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

***p < 0.001
In the interactive learning dimension, there was a significant difference in the mean scores for the medium- (M = 3.84) and high-blend (M = 3.70) courses, with a small effect size (F(2,1012) = 5.05, p < 0.01, \( \eta^2 = 0.01 \)), while the score for the medium-blend environments was significantly higher than that for the high-blend environments (d = 0.23).

In the reflective learning dimension, the mean scores for the low- (M = 3.64), medium- (M = 3.90) and high-blend (M = 3.64) courses showed a significant difference, with a small effect size (F(2,1012) = 21.72, p < 0.001, \( \eta^2 = 0.04 \)); the medium-blend courses produced a significantly higher score than the low- (d = 0.41) and high-blend (d = 0.43) courses.

**Background Variables**

**Gender**

A two-way MANOVA (Table 6) revealed that no significant gender—blend type interaction effects existed in the higher-order cognitive learning (F(1,1009) = 1.07, p > 0.05), interactive learning (F(1,1009) = 0.82, p > 0.05), and reflective learning (F(1,1009) = 0.28, p > 0.05) dimensions. Furthermore, there were no significant main effects of gender (F(1,1009) = 0.18, p > 0.05; F(1,1009) = 0.81, p > 0.05; F(1,1009) = 0.97, p > 0.05), indicating that male and female students had similar deeper learning perceptions.

Table 5. Perceived deeper learning differences in different blend types

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Blend Type</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>F</th>
<th>Post Hoc</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCL</td>
<td>Low</td>
<td>175</td>
<td>3.51</td>
<td>0.56</td>
<td>8.12***</td>
<td>Medium &gt; Low, Medium &gt; High</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>635</td>
<td>3.64</td>
<td>0.65</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>205</td>
<td>3.46</td>
<td>0.60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IL</td>
<td>Low</td>
<td>175</td>
<td>3.72</td>
<td>0.61</td>
<td>5.05 **</td>
<td>Medium &gt; High</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>635</td>
<td>3.84</td>
<td>0.64</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>205</td>
<td>3.70</td>
<td>0.59</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RL</td>
<td>Low</td>
<td>175</td>
<td>3.64</td>
<td>0.63</td>
<td>21.72***</td>
<td>Medium &gt; Low, Medium &gt; High</td>
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<tr>
<td></td>
<td>Medium</td>
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<td>3.90</td>
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<td></td>
<td>High</td>
<td>205</td>
<td>3.64</td>
<td>0.59</td>
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</table>

**p < 0.01, ***p < 0.001

Table 6. Gender differences

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Gender</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>F1</th>
<th>F2</th>
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<tbody>
<tr>
<td>HCL</td>
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<td>0.67</td>
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<tr>
<td></td>
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<td></td>
<td>Female</td>
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</tr>
<tr>
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<td>3.77</td>
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<td></td>
<td>Female</td>
<td>536</td>
<td>3.83</td>
<td>0.63</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < 0.05; F1 = gender, F2 = gender | blend type
School Year

The results (Table 7) suggested that no significant school year - blend type interaction effects were observed in the higher-order cognitive learning dimension (F(6,1003) = 6.33, p > 0.05), but there was a small school year main effect (F(3,1003) = 6.33, p < 0.001, η² = 0.02). The Scheffé’s post hoc analysis showed that senior and junior students saw themselves more capable of deeper learning than freshmen (d = 0.42 and d = 0.30, respectively).

Furthermore, the results revealed significant school year-blend type interaction effects on students’ perceptions of interactive learning (F(6,1003) = 2.66, p < 0.05, η² = 0.02) and reflective learning (F(6,1003) = 2.85, p < 0.001, η² = 0.02).

In the interactive learning dimension (Figure 3), significant differences existed among students in the low-blend courses, with a small effect size (F(3,171) = 3.26, p < 0.05, η² = 0.05). A post hoc analysis showed that seniors’ perceptions (n = 16, M(SD) = 4.14(0.65)) were significantly higher than freshmen’s perceptions (n = 86, M(SD) = 3.65(0.69)), with a medium effect size (d = 0.73). While no significant differences existed among the students in the medium-blend courses (F(3,631) = 1.34, p > 0.05), significant differences were found in the high-blend courses, with a medium effect size (F(3,201) = 8.44, p < 0.001, η² = 0.11). Seniors’ perceptions (n = 9, M(SD) = 4.49(0.63)) were significantly higher than the perceptions of juniors (n = 30, M(SD) = 3.87(0.46)), sophomores (n = 68, M(SD) = 3.70(0.55) and freshmen (n = 98, M(SD) = 3.58(0.58)), with a large effect size (d = 1.12, d = 1.34, d = 1.50, respectively).

As for the reflective learning dimension (Figure 4), significant differences existed among the students in the low-blend courses, with a large effect size (F(3,171) = 9.05, p < 0.001, η² = 0.14). According to a post hoc analysis, seniors reported significantly higher reflective learning perceptions (n = 16, M(SD) = 4.36(0.70)) than juniors (n = 12, M(SD) = 3.72(0.53); d = 1.03), sophomores (n = 61, M(SD) = 3.54(0.42); d = 1.42), and freshmen (n = 86, M(SD) = 3.56(0.68); d = 1.16). Furthermore, significant differences existed in the medium-blend courses, with a small effect size (F(3,631) = 3.24, p < 0.05, η² = 0.02); seniors perceived their reflective learning abilities (n =

<table>
<thead>
<tr>
<th>Table 7. School year differences</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dimension</strong></td>
</tr>
<tr>
<td>HCL</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
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</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
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<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

*p < 0.05, **p < 0.01, ***p < 0.001; F¹ = school year, F² = school year Í blend type
145, M(SD) = 4.04(0.59)) significantly higher than freshmen (n = 147, M(SD) = 3.83(0.46); d = 0.40). Finally, there were significant differences in the high-blend courses, with a small effect size (F(3,201) = 4.28, p < 0.05, η² = 0.06). The perceptions of freshmen (n = 98, M(SD) = 3.50(0.60)) were significantly lower than those of seniors (n = 9, M(SD) = 4.00(0.72); d = 0.75), juniors (n = 30, M(SD) = 3.83(0.17); d = 0.73), and sophomores (n = 68, M(SD) = 3.70(0.64); d = 0.31).

Field of Study
There was no significant field of study-blend type interaction effects (Table 8) on any dimensions (HCL (F(2,1009) = 0.68, p > 0.05), IL (F(2,1009) = 0.01, p > 0.05), and RL (F(2,1009) = 0.01, p > 0.05)). No significant differences were found between different fields of study in the higher-order cognitive learning dimension (F(1,1009) = 1.39, p > 0.05). However, significant field of study main effects were observed in the interactive learning (F(1,1009) = 6.61, p < 0.05) and reflective learning dimensions (F(1,1009) = 9.95, p < 0.01), where the humanities and social science (HSS) students reported higher perceived abilities than their natural science (NS) counterparts, with a small effect size (η² = 0.01 and η² = 0.01, respectively).
DISCUSSION

This study developed a scale to assess students’ deeper learning perceptions and examined college students’ background differences in perceived deeper learning in the three dimensions, in general, and in the three blend types, specifically. The findings revealed differences among the students of various school years and majors.

The first research question assessed deeper learning perceptions in the blended learning environments. The results demonstrated that college students’ experiences in the blended courses were positive. This could be attributed to collaborative and active learning afforded by blended learning environments (Geng et al., 2019), which provide more opportunities for students to improve their deeper learning competencies. For instance, active participation in group activities and effective collaboration with others appears to foster cognitive and metacognitive skills (Dwyer & Walsh, 2020). Similarly, according to Simsek (2020), collaborative digital storytelling can stimulate creative and practical thinking. In the same vein, Bishnoi (2020) found that active and collaborative learning in the flipped classroom enabled college students to acquire the required professional skills.

Additionally, higher interactive learning and reflective learning scores may indicate that blended learning was more beneficial for students’ interactions and self-monitoring than higher-order cognition. This may be due to the flexibility of online learning, which allowed students to learn at their own pace, giving them sufficient time to think and have in-depth discussions as they completed their learning tasks. Zhu and Bonk (2019) suggested that online reflection questions and online learning communities played a vital role in supporting students’ self-monitoring, and the blended learning model effectively improved students’ communication skills (Hasanah & Malik, 2020). However, Chen and Du (2022) reported that collaborative learning activities integrated in online learning did not necessarily contribute to higher-order cognitive learning development. Hence, it could be speculated that blended learning appears to cultivate interaction and reflection skills more effectively.

Students who participated in the medium-blend courses perceived themselves to be more capable of deeper learning. This finding supports Owston and York’s (2018) conclusion that students tended to prefer classes with a blend of about 50%. As a relatively moderate 40% to 60% proportion, medium-blend courses may be conducive to teachers making full use of the two learning forms and integrating online and face-to-face learning activities to achieve an optimal instructional design for students’ deeper learning. In contrast, the resource access issues in the low-blend courses and technical challenges in the high-blend courses may hinder students’ deeper learning. As learning resources mainly come from teachers’ delivery in a face-to-face classroom, students’ individual needs might not be met (Mather & Sarkans, 2018), which renders students’ performance poorer. Furthermore, blended learning students prefer using a single tool and do not like to switch between multiple tools (Gitinabard et al., 2019). Accessing course information and completing tests online, for instance, might affect students’ knowledge mastery since they require different tools, which they highly

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Field of Study</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>F&lt;sub&gt;1&lt;/sub&gt;</th>
<th>F&lt;sub&gt;2&lt;/sub&gt;</th>
</tr>
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<tbody>
<tr>
<td>HCL</td>
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<td>1.39</td>
<td>0.68</td>
</tr>
<tr>
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<td>NS</td>
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<td>0.66</td>
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<tr>
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<td>HSS</td>
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<tr>
<td></td>
<td>NS</td>
<td>405</td>
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<td>HSS &gt; NS</td>
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<td>405</td>
<td>3.73</td>
<td>0.67</td>
<td>HSS &gt; NS</td>
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</tr>
</tbody>
</table>

*p < 0.05, **p < 0.01; F<sub>1</sub> = field of study, F<sub>2</sub> = field of study × blend type
depend on (Hermanto & Srimulyani, 2021). Although the medium-blend courses produced higher perceptions, the effect size was small. Teachers should provide more auxiliary resources, prevent technical difficulties, and utilize timely interaction in the face-to-face classroom and flexibility of online learning to promote students’ deeper learning.

The second research question focused on the background differences in students’ deeper learning perceptions in different blended environments. First, no gender differences were observed in deeper learning perceptions. This finding adds to the previous studies on blended learning, which found that gender did not affect students’ final exam scores (Bazelaïs & Doleck, 2018), and that male and female participants exhibited similar levels of learning motivation, communication, and learner control in online learning (Hung et al., 2010) as well as student engagement (Kundu et al., 2021). Therefore, this may indicate that both males and females can skillfully use various digital learning tools to have equal access to learning resources, which reflects the advantages of technology-supported blended learning environments.

Second, in the higher-order cognitive learning dimension, seniors and juniors had better self-perceptions than freshmen. Since seniors and juniors have spent more time in college, they could have participated in more blended learning courses, which, with proper learning strategies, were effective at enhancing students’ higher-level thinking skills (Haryadi et al., 2021). It is also possible that mature students prefer online delivery (Mather & Sarkans, 2018) as more mature learners require less supervision and can be more self-determined in their learning (Blaschke, 2019), thus achieving success in online education (Xie et al., 2020).

In the interactive learning dimension, the school year differences were more pronounced in the high-blend courses than those in the low- and medium-blend courses. The large effect size for pairwise comparisons of seniors’ perceptions with the perceptions of other school years in the high-blend environments might be explained by prior exposure to this type of learning. Although online learning is more conducive to students’ participation in interactive activities and academic discussions (Mou, 2020) and enables even introverted students to express their opinions on the Internet more willingly (Onyema et al., 2019), it requires practice to be an effective communication and collaboration means. Therefore, in the high-blend courses, seniors may have had more opportunities in the previous years to improve their online communication and collaboration than juniors, sophomores, and freshmen, resulting in larger school year differences in interactive learning.

In the reflective learning dimension, students’ school year differences in the low-blend courses produced a large effect size. This finding could be explained by the additive effect of reflective classroom activities over the years. As facilitators of face-to-face learning, teachers could guide students to think and give feedback more effectively (Ashraf et al., 2021) to inspire deep reflection (Li & Tsai, 2020). Gillingham et al. (2020) found that due to scarce comments from teachers, students’ reflections on online forums were mostly superficial and lacked depth. Thus, in the low-blend courses, senior students may have participated in more classroom reflective activities over the years, resulting in a large effect size of school year differences in reflective learning.

Third, higher-order cognitive learning perceptions were similar for both study fields in all blend types. This may be because college students of any major could make full use of digital learning resources, which foster a deep and comprehensive understanding of materials (Tlhoaele et al., 2016). However, in the interactive learning and reflective learning dimensions, the humanities and social science students considered their deeper learning abilities to be better than the natural science students, which could be attributed to different disciplinary characteristics promoting different learning styles (Lau & Gardner, 2019) and, consequently, different perceived interactive learning and reflective learning. Natural science students may prefer independent thinking (Zulfah & Aznam, 2018), which may be detrimental to the development of students’ interactive and reflective learning. In contrast, humanities and social science students may favor debates and discussions to enhance their language expression ability (Avsec & Szewczyk-Zakrzewska, 2017),
improve their learning achievement (Tee et al., 2019), and make them interact with others more (Chilvers et al., 2021). For example, online collaborative writing in English classes, interaction between students and teachers, and information sharing and communication among students cultivated students’ social skills and developed students’ critical thinking (Yan, 2019), while the freedom to explore and learn on their own in physics classes led to insufficient interactive learning skills (Faries et al., 2019).

In summary, college students can engage in deeper learning comprehensively and effectively in the technology-supported blended learning environments. Teachers should appropriately employ digital tools in learning resource construction to account for background and blend type differences to maximize deeper learning outcomes.

CONCLUSION AND LIMITATIONS

This study proposed a scientific and effective DLSS, which was tested on a large sample of students, to investigate the self-perceptions of deeper learning in higher-order cognitive learning, interactive learning, and reflective learning dimensions among blended learning college students. Then, it explored the background differences in students’ self-perceived deeper learning in the low-, medium- and high-blend learning environments.

This study’s findings can serve as a basis for instructional design optimization to cater to the diverse needs of college students in blended learning environments, which is particularly important in the post-pandemic era where blended learning may become a new normal in higher education. It is helpful for teachers to understand the current level of college students’ deeper learning and determine possible problems in the implementation of blended courses. Although college students’ deeper learning perceptions were positive, the participants felt more capable of interactive and reflective learning than of higher-order cognitive learning. In Addition, the fact that the humanities and social science disciplines demonstrated higher perceptions than the natural science disciplines in the interaction and reflection dimensions is a reminder that teachers should tailor their curriculum to the needs of students majoring in different disciplines and adopt appropriate instructional activities or strategies to promote students’ interactive and reflective learning. Since school year differences were related to the blend types in the interactive and reflective learning dimensions, teachers may consider providing more support to younger students in the low- and high-blend environments. Teachers may guide students to reflect through questions and debates in the classroom, and interact with students timely via audio lectures, videos, and emails online.

Nevertheless, this study has two limitations. Firstly, this study only examined deeper learning perceptions of students who experienced this type of learning. Although the sample was large, there was no point of reference a control group would provide. Secondly, this study did not differentiate among subjects, teachers, and learning strategies, which may affect deeper learning.

In the future, to improve results accuracy and to make the sample more representative, the authors will adopt a quasi-experimental research design and select blended and traditional classroom students. Furthermore, future research should focus on the influence of different teaching approaches on college students’ deeper learning in blended learning environments.

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CONFLICT OF INTEREST

The authors of this publication declare that there is no conflict of interest.
REFERENCES


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